Agency for Healthcare Research and Quality
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NATIONAL GUIDELINE CLEARINGHOUSE

General

Guideline Title

ACR Appropriateness Criteria® renal transplant dysfunction.

Bibliographic Source(s)

Dighe M, Remer E, Casalino D, Bishoff JT, Blaufox MD, Coursey CA, Eberhardt SC, Goldfarb S, Harvin HJ, Lazarus E, Leyendecker JR, Lockhart ME, Nikolaidis P, Oto A, Porter C, Sheth S, Vikram R, Expert Panel on Urologic Imaging. ACR Appropriateness CriteriaÂ® renal transplant dysfunction. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 7 p. [55 references]

Guideline Status

This is the current release of the guideline.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Renal Transplant Dysfunction

Radiologic Procedure	Rating	Comments	RRL*
US kidney transplant	9		O
Tc-99m MAG3 scan kidney	7		
Tc-99m DTPA scan kidney	5		
CT abdomen and pelvis with contrast	5		

Radiologic Procedure	Rating	Comments	RRL*
Arteriography kidney	5	After noninvasive vascular assessment has been performed. To confirm RAS or other vascular abnormality and guide treatment.	
CT abdomen and pelvis without and with contrast	4	Noncontrast phase may be beneficial in assessing hemorrhage, vascular calcifications, and stones.	
CT abdomen and pelvis without contrast	4		
MRI abdomen and pelvis without and with contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI abdomen and pelvis without contrast	4		O
X-ray intravenous urography	1		
X-ray antegrade pyelography	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

According to the Organ Procurement and Transplantation Network of the U.S. Health Resources and Services Administration, almost 330,000 renal transplants have been performed in the United States since 1988. In 2011 alone, 16,813 renal transplants were performed, of which 11,043 were from deceased donors and 5,770 were from living donors. Renal transplant dysfunction can lead to renal failure, a devastating event, and every effort is made to address dysfunction by management of immunosuppression and transplant complications. Five-year survival rates for the graft in renal transplant patients range from 72% to 99%, with the best rates seen in patients receiving kidneys from living donors.

Causes for renal transplant dysfunction include acute tubular necrosis (ATN), rejection, toxicity from medications, renal artery stenosis (RAS), renal vein thrombosis, and postbiopsy renal arteriovenous malformations. ATN is seen in the immediate post-transplant period in a high percentage of cadaver grafts but only infrequently in living related donors. Acute rejection typically occurs at least 4 to 5 days after transplantation. The incidence of RAS varies from 1.8% to 12% in the literature and presents as refractory hypertension or increasing serum urea and creatinine levels.

Ultrasound (US) is the modality of choice to evaluate renal transplants early in the postoperative period but also in long-term follow-up as well. US is also used to guide diagnostic and therapeutic interventions such as biopsy or fluid aspiration. Radionuclide imaging is an excellent modality for assessing graft function both qualitatively and quantitatively. Computed tomography (CT) and magnetic resonance imaging (MRI) can provide information about structural abnormalities like stenosis and thrombosis. Angiography is used for treatment of complications like stenosis or arteriovenous malformations.

Ultrasound

As renal transplants typically are located anteriorly in the pelvis, they usually are readily visible with US. US is a valuable tool in the immediate

post-transplant period as well as for long-term follow-up. Typically, gray scale images are obtained to evaluate for transplant hydronephrosis, peritransplant fluid collections, and renal cortical thickness. Color Doppler images are obtained to evaluate the patency and direction of flow in transplant arteries and veins. Spectral analysis of vascular waveforms and velocities can provide information about a range of pathologies such as RAS. The lack of potentially nephrotoxic iodinated contrast agents is an advantage of US over CT. Furthermore, an advantage of US over MRI is avoidance of the risk of developing nephrogenic systemic fibrosis (NSF) as a result of gadolinium-based contrast agents. The operator dependence of US is, however, a relative limitation.

US is used as a routine study to evaluate the transplant within the first 24 hours after transplantation to detect or rule out vascular pathology. In the perioperative period, US can detect renal artery thrombosis or renal vein thrombosis. It is also commonly used for first-line evaluation in the setting of transplant dysfunction. B-mode appearance seen on US includes a reduction in corticomedullary differentiation, reduction in renal sinus echoes, increased and reduced renal parenchymal echoes, increased cortical reflectivity. However, these features occur well after the onset of the dysfunction and are arbitrary and inconsistent and hence of limited value. Studies have suggested that resistive index (RI) measured by duplex Doppler US is not sensitive or specific in identifying the cause of functional transplant dysfunction. In 145 examinations of 81 patients, a group of researchers found a sensitivity of 13%, a specificity of 100%, a positive predictive value (PPV) of 100%, and a negative predictive value (NPV) of 66% in making the diagnosis of acute rejection with duplex Doppler US. Another group found a sensitivity of 9%, specificity of 91%, PPV of 29% and a NPV of 70% using an RI cut off of 0.90 for the diagnosis of allograft rejection. However, recent studies have shown that renal arterial RI is useful in predicting graft survival, especially when using a lower RI cut-off of 0.8. Using a cut-off of 0.80, one study found that 47% of patients with RI >0.80 developed chronic allograft nephropathy (CAN) compared to 9% of patients with RI <0.80 in the first 3 months after transplantation. Another study found both RI and pulsatility index (PI) measured between week 1 and 3 months significantly correlated with the 1-year estimated glomerular filtration rate (eGFR). Abnormal resistive indices indicate allograft dysfunction but do not reliably demonstrate the cause.

Doppler US is also a very reliable and noninvasive tool to monitor the effectiveness of revascularization in patients with RAS. Tardus parvus waveform can be seen within the kidney downstream to the stenosis; however, due to the superficial location of the transplant kidney, evaluation of the main renal artery is better. Peak systolic velocity (PSV) in the renal artery is commonly used as the parameter to assess for the presence of RAS on US. Cut-off values of 200 to 300 cm/second have been proposed in various studies. One study reported a sensitivity of 90% to 96.8% and a specificity of 87.5% to 70% using PSV in the main renal artery and a sensitivity of 100% and specificity of 96.7% using an acceleration time (AT) of 0.09 or less as normal. Another parameter that can be used is the renal to iliac artery ratio (RIR), which has been shown to have a sensitivity of 90% and specificity of 96.7% using a cut off value of 1.8. A recent study found that a PSV of 285 cm/second or renal-aortic ratio (RAR) of 3.7 alone was better than any combination of PSVs, end-diastolic velocities (EDVs), or RARs in detecting ≥60% stenosis.

As for other modalities, the evaluation of accessory arteries may contribute to reduced sensitivity and specificity for arterial stenosis. As evaluation for RAS with US is operator dependent, magnetic resonance angiography (MRA) or CT angiography (CTA) may be more reliable in centers with little experience evaluating for RAS with US. US appearance of renal artery thrombosis is striking, with complete absence of flow in the renal vessels on color flow and spectral analysis. It is important to remember, however, that absent flow within the kidney can also be seen in patients with hyperacute rejection and renal vein thrombosis. Reversal of flow in the renal artery in diastole has been seen in renal vein thrombosis; however, this reversal has been shown in ATN, rejection, low cardiac output, and nephrosclerosis as well. US is a useful tool for detection of post-biopsy arteriovenous fistulas, which can affect allograft function if they are large.

US can identify postoperative fluid collections like abscess, hematoma, lymphocele, and urinoma, but it cannot differentiate between them. In order to differentiate these entities, aspiration is required, and this is commonly performed with US guidance. Hydronephrosis can also be easily identified with US; however, it should be interpreted in correlation with biochemical data since reflux can give a similar appearance as well. Urine leak may appear as a fluid collection on US, but isotope scan would be more helpful.

US is also useful in guiding renal transplant biopsies since serum creatinine is insensitive for detecting early graft pathology and cannot be relied on for assessment of adequacy of immunosuppression. The complication rate from renal transplant biopsies is low, with a reported rate of 0.4% to 1% graft loss in approximately 2,500 biopsies.

Contrast-enhanced ultrasound (CES) has been used by some investigators to evaluate graft perfusion not only in large arteries but within the cortex as well. A group of researchers were able to identify patients with vascular rejection using CES. Another group found that patients with CAN had significantly lower blood flow values quantified by CES compared to patients without CAN.

Computed Tomography

CT has not been typically used to evaluate renal transplant dysfunction due to concerns of nephrotoxicity from iodinated contrast; however, in patients with suspected RAS, CT can provide additional information before a percutaneous angiography is performed. CT angiography (CTA) allows for anatomic depiction in great detail and has a high diagnostic accuracy for detecting vascular complications. Data about the usefulness of CT in evaluating transplant RAS are limited. One study found abnormalities on CT in 42% of cases, like renal infarction, renal vein stenosis, and

arteriovenous fistula, when US was unremarkable. Another group of investigators found that CTA and MR angiography (MRA) appear to have comparable negative predictive accuracy in evaluating suspected RAS. They found that CTA had sensitivity, specificity, PPV, and NPV of 94%, 93%, 71%, and 99%, respectively. CTA, however, has the drawback of contrast-induced nephrotoxicity and radiation exposure in addition to insensitivity to mild RAS. Hence iodinated contrast agents should be used with caution in patients with renal dysfunction due to potential nephrotoxicity. In addition to vascular complications, a noncontrast CT could also be used to assess for hydronephrosis and change in the size of fluid collections.

Magnetic Resonance Imaging

MRI is being increasingly used for renal arterial visualization in renal transplants to assess for RAS. In addition, there are concerns about toxicity from gadolinium in this patient population causing NSF. However, due to the noninvasive nature of the examination, MRA has been used for evaluating RAS in post-transplantation patients.

MRA increased the diagnostic confidence in referring patients for conventional angiography with a change in management in approximately 65% of patients. One study involving both native and transplant renal arteries found that preprocedural planning with use of gadolinium-enhanced MRA significantly reduced the iodinated contrast material requirement during percutaneous renal artery interventions, in addition to shortening the procedure duration. Another study on native renal arteries found that MRA had sensitivity, specificity, PPV, and NPV of 90%, 94.1%, 75%, and 98%, respectively, while a third study found sensitivity, specificity, PPV, and NPV of 97%, 67%, 90%, and 86%, respectively for diagnosing RAS. MRA, however, suffers from a few pitfalls that may lead to false diagnosis of stenosis or overestimation of a stenosis. These include artifacts caused by metallic surgical clips near the transplant artery that result in signal drop overlying the vessel, giving the false impression of stenosis, and bright signal at the margin of the signal drop in the soft tissue next to the renal allograft due to metallic clips, and venous overlaps due to inaccurate timing of the arterial bolus. Careful evaluation of the source images and multiplanar reformats will help solve these problems. In addition to depicting areas of stenosis in the main renal artery, MRA is also able to depict areas of infarction within the kidney which may be seen as areas of heterogeneous T1 and T2 signal intensity and as focal areas of nonenhancement on the postcontrast images. A group of investigators in their study on transplant renal arteries showed a sensitivity of 93.7%, specificity of 80%, and accuracy of 88.5%. In addition, outer cortical necrosis, cortical necrosis with large patches, diffuse cortical necrosis, and both cortical and medullary necrosis are also visualized on postcontrast images. Changes in the corticomedullary differentiation have been described in postrenal transplant patients with cyclosporine toxicity, rejection, and ATN. Another group described high MRI accuracy in diagnosing rejection when the corticomedullary differentiation is lost on postcontrast MRI compared to scintigraphy and US, with sensitivity, specificity, and PPV of 98%, 75%, and 72%, respectively; however this finding is nonspecific since it is seen in other etiologies as mentioned previously.

Newer techniques like nonenhanced MRA with steady-state free precession imaging can help avoid contrast in these patients and avoid the risk of NSF. Blood oxygen level dependent (BOLD) imaging depends on contrast generated by changing levels of paramagnetic deoxyhemoglobin with a decrease in intrarenal T2 during hypoxia taken as a reflection of increasing concentrations of deoxyhemoglobin. BOLD imaging can noninvasively detect change in intrarenal oxygenation and renal hypoxia induced by RAS. Parallel imaging has the major virtue of reducing acquisition times while preserving spatial resolution. One study demonstrated that parallel imaging could be used in renal MRA to improve spatial resolution while maintaining a reasonable acquisition time: the authors achieved resolution on the order of 1 mm^3.

X-ray Intravenous Urography and Pyelography

X-ray intravenous urography and pyelography are no longer used for evaluation of the renal transplant.

Nuclear Medicine

Radionuclide tests are valuable in renal transplantation since they provide a noninvasive means to evaluate transplant function qualitatively and also screen for surgical complications. Only scintigraphic studies are able to separate function of the graft from residual function of the native kidneys or any remaining prior failed graft. There are a wide variety of techniques advocated in renal transplants. The most commonly used procedure is renal scintigraphy with combined imaging. In many centers, baseline scintigraphic studies are obtained shortly after transplant; in others they are only done when complications occur. An advantage of renography is that it provides functional information at the time of the study, while creatinine lags behind function, and radiographic studies are primarily anatomic. Because of this it can be helpful in evaluating the return of function after ATN or rejection.

Use in differential diagnosis of ATN and rejection is controversial. One study found that renogram performed early after transplantation could predict primary graft nonfunction, long time to graft function, low discharge chromium-labeled ethylenediaminetetraacetic acid (Cr EDTA) clearance, and low 1- and 5-year graft survival, while renogram performed at discharge could predict late (>6 months) graft loss. However, the renogram changes did not contribute to the differential diagnosis between acute rejection, acute tubulointerstitial nephropathy, and cyclosporine toxicity. In obstruction it can be used with Lasix as it is in native kidneys. Urinary leaks may be identified by the presence of radioactivity in an

abnormal location. If hypertension develops in the patient, captopril renography can definitively identify the transplant and RAS as the cause. In some centers and especially in Europe renal clearances are performed serially to evaluate renal function. These are done less frequently in the United States.

Numerous quantitative indices are used to evaluate transplants, but no single one has achieved acceptance, although it appears they may be useful. Technetium (Tc)-99m diethylene triamine pentaacetic acid (DTPA) or Tc-99m mercaptoacetyltriglycine (MAG3) may be used to follow the transplant. MAG3 is preferred because of the better images it provides. Usually both renograms and images are obtained simultaneously. DTPA offers similar information when assessing renal function.

Angiography

Percutaneous therapeutic angioplasty (PTA) and stenting (PTAS) is the treatment of choice for RAS, with a reported success rate of 65% to 100%. The complication rate of PTA and PTAS is low at approximately 0% to 10% compared to surgery, which has a graft loss rate of 15% and mortality rate of 5%. However, one long-term study over a 24-year period found a complication rate of 25.5% (usually without clinical sequelae); however, similar data is not available for surgical cases. The restenosis rate after PTA alone is higher than with PTAS, with a rate of 10% to 33% over 6 to 8 months. A group of researchers found a technical success rate of 100% with no acute complications and amelioration of arterial hypertension and improvement of graft function within 7 postoperative days. In the follow-up period, 81.8% of their patients had normal blood pressure and creatinine levels. In another large study involving 44 patients, the technical success rate was 100% and the clinical success rate was 86%, suggesting that PTA and PTAS are safe procedures to perform in renal transplant patients.

Superselective embolization is also effective in treating postbiopsy arteriovenous fistulae in renal transplants with minimal loss of renal parenchyma.

Summary

- Renal transplant dysfunction is a devastating event, and appropriate management of the immunosuppression and complications that arise in these patients is necessary to avoid graft failure.
- US is the primary modality for evaluating renal transplant dysfunction.
- Radionuclide tests using Tc-99m MAG3 or Tc-99m DTPA can evaluate renal transplant function qualitatively and screen for surgical complications.
- MRI and CT can also be used for evaluating renal transplants; however, MRI suffers from lack of resolution and concerns about gadolinium toxicity in a population at risk of renal dysfunction.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m^2. For more information, please see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Abbreviations

- CT, computed tomography
- DTPA, diethylene triamine pentaacetic acid
- MAG3, mercaptoacetyltriglycine
- MRI, magnetic resonance imaging
- RAS, renal artery stenosis
- Tc, technetium
- US, ultrasound

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
	<0.1 mSv	<0.03 mSv
	0.1-1 mSv	0.03-0.3 mSv
	1-10 mSv	0.3-3 mSv
	10-30 mSv	3-10 mSv
	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Renal transplant dysfunction

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Critical Care

Internal Medicine

Nephrology

Nuclear Medicine

Radiology

Surgery

Intended Users

Health Plans

Hospitals

Managed Care Organizations

Physicians

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of initial radiologic examinations for patients with renal transplant dysfunction

Target Population

Patients with renal transplant dysfunction

Interventions and Practices Considered

1. Ultrasound (US) kidney transplant
2. Technetium (Tc)-99m mercaptoacetyltriglycine (MAG3) scan kidney
3. Tc-99m diethylene triamine pentaacetic acid (DTPA) scan kidney
4. Computed tomography (CT) abdomen and pelvis
    - With contrast
    - Without and with contrast
    - Without contrast
5. Arteriography kidney
6. Magnetic resonance imaging (MRI) abdomen and pelvis
    - Without and with contrast
    - Without contrast
7. X-ray
    - Intravenous urography
    - Antegrade pyelography

Major Outcomes Considered

Accuracy, sensitivity, specificity, and positive and negative predictive value of radiologic procedures for evaluating renal transplant dysfunction

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Procedure

The Medline literature search is based on keywords provided by the topic author. The two general classes of keywords are those related to the condition (e.g., ankle pain, fever) and those that describe the diagnostic or therapeutic intervention of interest (e.g., mammography, MRI).

The search terms and parameters are manipulated to produce the most relevant, current evidence to address the American College of Radiology Appropriateness Criteria (ACR AC) topic being reviewed or developed. Combining the clinical conditions and diagnostic modalities or therapeutic procedures narrows the search to be relevant to the topic. Exploding the term "diagnostic imaging" captures relevant results for diagnostic topics.

The following criteria/limits are used in the searches:

1. Articles that have abstracts available and are concerned with humans.
2. Restrict the search to the year prior to the last topic update or in some cases the author of the topic may specify which year range to use in the search. For new topics, the year range is restricted to the last 5 years unless the topic author provides other instructions.
3. May restrict the search to Adults only or Pediatrics only.

4. Articles consisting of only summaries or case reports are often excluded from final results.

The search strategy may be revised to improve the output as needed.

Number of Source Documents

The total number of source documents identified as the result of the literature search is not known.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Strength of Evidence Key

Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis, and results.

Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.

Category 3 - The conclusions of the study may be valid, but the evidence supporting the conclusions is inconclusive or equivocal.

Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis.

Methods Used to Analyze the Evidence

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author drafts or revises the narrative text summarizing the evidence found in the literature. American College of Radiology (ACR) staff draft an evidence table based on the analysis of the selected literature. These tables rate the strength of the evidence for all articles included in the narrative text.

The expert panel reviews the narrative text, evidence table, and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the table. Each individual panel member forms his/her own opinion based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Modified Delphi Technique

The appropriateness ratings for each of the procedures included in the Appropriateness Criteria topics are determined using a modified Delphi methodology. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. American College of Radiology (ACR) staff distributes surveys to the panelists along with the evidence table and narrative. Each panelist interprets the available evidence and rates each

procedure. The surveys are completed by panelists without consulting other panelists. The ratings are a scale between 1 and 9, which is further divided into three categories: 1, 2, or 3 is defined as "usually not appropriate"; 4, 5, or 6 is defined as "may be appropriate"; and 7, 8, or 9 is defined as "usually appropriate." Each panel member assigns one rating for each procedure per survey round. The surveys are collected and the results are tabulated, de-identified and redistributed after each round. A maximum of three rounds are conducted. The modified Delphi technique enables each panelist to express individual interpretations of the evidence and his or her expert opinion without excessive bias from fellow panelists in a simple, standardized and economical process.

Consensus among the panel members must be achieved to determine the final rating for each procedure. Consensus is defined as eighty percent (80%) agreement within a rating category. The final rating is determined by the median of all the ratings once consensus has been reached. Up to three rating rounds are conducted to achieve consensus.

If consensus is not reached, the panel is convened by conference call. The strengths and weaknesses of each imaging procedure that has not reached consensus are discussed and a final rating is proposed. If the panelists on the call agree, the rating is accepted as the panel's consensus. The document is circulated to all the panelists to make the final determination. If consensus cannot be reached on the call or when the document is circulated, "No consensus" appears in the rating column and the reasons for this decision are added to the comment sections.

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current literature and expert panel consensus.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of patients with renal transplant dysfunction

Potential Harms

- Computed tomography (CT) and CT angiography (CTA) have the drawback of contrast-induced nephrotoxicity and radiation exposure.
- Magnetic resonance angiography (MRA) suffers from a few pitfalls that may lead to false diagnosis of stenosis or overestimation of a stenosis. These include artifacts caused by metallic surgical clips near the transplant artery that result in signal drop overlying the vessel,

giving the false impression of stenosis, and bright signal at the margin of the signal drop in the soft tissue next to the renal allograft due to metallic clips, and venous overlaps due to inaccurate timing of the arterial bolus.

Gadolinium-based Contrast Agents

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Relative Radiation Level (RRL)

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Dighe M, Remer E, Casalino D, Bishoff JT, Blaufox MD, Coursey CA, Eberhardt SC, Goldfarb S, Harvin HJ, Lazarus E, Leyendecker JR, Lockhart ME, Nikolaidis P, Oto A, Porter C, Sheth S, Vikram R, Expert Panel on Urologic Imaging. ACR Appropriateness CriteriaÂ® renal transplant dysfunction. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 7 p. [55 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2012

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Urologic Imaging

Composition of Group That Authored the Guideline

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

Guideline Availability

Electronic copies: Available from the American College of Radiology (ACR) Web site .

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site .
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Evidence table development – diagnostic studies. Reston (VA): American College of Radiology; 2013 Nov. 3 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 90 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site .
- ACR Appropriateness Criteria® renal transplant dysfunction. Evidence table. Reston (VA): American College of Radiology; 2012. 25 p. Electronic copies: Available from the ACR Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on May 9, 2013.

Copyright Statement

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NGC Disclaimer

Inclusion Criteria which may be found at http://www.guideline.gov/about/inclusion-criteria.aspx.

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